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Index, Vol. VIII

	PAGE
Certain Oils Obtained from Resinous Woods—M. R. Shaw, B.A.Sc., '09....	1
Difficulties in Construction—C. S. L. Hertzberg, B.A.Sc., '05.....	7
Fireproof Building Construction—G. M. Cook, B.A.Sc., '13.....	11
Points Concerning Reinforced Concrete Abutments—H. R. Mackenzie, B.A.Sc., '13.....	25
Design of a Structural Steel Plant—E. H. Darling, M.E., '98.....	38
Vector Algebra—A. Macfarlane, D.Sc., LL.D.....	54
Three-Phrase Transformation—Chas. H. Russell, B.A.Sc., '13.....	61
Plate Girder Bridges in Railway Construction—C. H. Marrs, C.E., '02....	77
Developments in the Manufacture of Pulp Wood—Geo. J. Manson, M.E., '04.	105
River Improvement—E. T. Ireson, B.A.Sc., '13.....	110
The Wood Preserving Industry.....	122
Dean Galbraith.....	127
Engineering as a Profession—Walter J. Francis, C.E., '93.....	131
Bridges and Sub-Marine Tunnels, H. G. Tyrrell, C.E., '86.....	139
A Really Greater New York—T. Kennard Thomson, C.E., '86.....	143
The Corrosion of Iron and Steel and its Prevention—H. C. Quail, B.A.Sc., '13	147
Railway Across Irish Channel—H. G. Tyrrell, C.E., '86.....	153
Gold—Wm. B. McPherson, B.A.Sc., '11.....	157
The Corrosion of Iron and Steel (Continued)—H. C. Quail, B.A.Sc., '13....	169
The New Massachusetts Institute of Technology.....	173
Aluminum—E. A. Twidale, B.A.Sc., '14.....	183
Twenty-fifth Annual Dinner of the Engineering Society.....	190
Evolution in the Art of Building—H. F. Ballantyne, B.A.Sc., '93.....	199
The Corrosion of Iron and Steel (Concluded)—H. C. Quail, B.A.Sc., '13....	210
Electric Smelting of Iron Ore in Canada—T. R. Loudon, B.A.Sc., '05.....	219
Biography—Prof. J. W. Bain, B.A.Sc., '96.....	224
Methods of Transferring Skill—Frank B. Gilbreth, C.E.....	227
Engineering and the Law—C. F. Elliott, B.A.Sc., '11.....	231
Test of a Russell-Knight "28" Engine—Prof. H. W. Price, B.A.Sc., '01.	237
The Extension of the Toronto Waterworks System (Continued)—Prof. R. W. Angus, B.A.Sc., '04.....	252
The Kinematograph at the University of Toronto—Prof. G. R. Anderson, M.A.....	266
The Wail of the Surveyor.....	273
The Extension of the Toronto Waterwork sSystem (Concluded)—Prof. R. W. Angus.....	275
Town Planning and Civic Improvement—Mr. C. H. Mitchell, C.E.....	284
A School Dinner in Ottawa....	294

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TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

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CERTAIN OILS OBTAINED FROM RESINOUS WOODS

BY M. R. SHAW, B.A.Sc.

This article is extracted from Mr. Shaw's report to the Engineering Alumni Association on his researches in the University of Toronto during the past year. The entire work does not lend itself to publication at the present time; and the following covers that part of his investigation to determine whether the pinon pine of New Mexico and the Jack pine of Ontario are commercially suitable for the manufacture of turpentine and other products from the percentage of volatile oil, as turpentine, and resin which they contain.—Ed.

Pinon pine is of economic importance because it covers extensive areas in regions too dry for other kinds of timber. It grows at an altitude of about 5,000 feet and may be found as high as 8,000 feet. It is small and grows to a height of from 10 to 35 feet, and from one-half to one and a half feet in diameter. Its crooked form, however, limits its commercial value to supplying fuel, posts, poles, and where size permits, for railroad ties.

Turpentine experiments as carried on by the United States Forest Service ¹ show that the average yield of dip or oleoresin from the trees when turpented was only a little over one-half the yield from the yellow pine of Florida.

An examination of the oleoresin from the pinon pine was carried on by the United States Forest Service ² showing that the percentage of volatile oil contains 70-75% α pinene, about 5% β pinene, and 15-20% cadinene. The oleoresin yields an acid of the formula $C_{20}H_{30}O_2$. The specific gravity of the volatile oil was 0.8680, the index of refraction $N_{D_{15}}$ was 1.4707 and 80% distills between 156° and 200°C. By removing the cadinene 75 to 80% of the oil could be collected up to 175°C, the distillate consisting mostly of α pinene, and β pinene, and would be similar to ordinary turpentine. The distillate, however, retains in part the characteristic odor of cadinene which might prove objectionable to the user.

The time was when turpentine was about the cheapest thing a housekeeper could buy. Turpentine has grown so in value that unless you specify that you want the genuine article, the dealer will give

(1). U. S. Forest Service. Bull. 116.

(2). U. S. Forest Service. Bull. 119.

you a substitute made largely of crude petroleum products. Some years ago turpentine retailed at twenty-cents a gallon, and now wholesale at about fifty cents. The turpentine areas of the south-east are rapidly diminishing and there seems to be no conservation of the timber areas. The trees are natural growth and cannot be restored by replanting, and their value will steadily increase making the price of turpentine beyond that of commercial use. The south-western States with their pellow pine and pinon wood, seem to be the only field left for turpentine working. Pinon pine, providing the yield of oil and resin is large enough to meet economic problems, seems to be the cheapest wood. During the civil war when turpentinizing operations in the south virtually ceased, some operations were carried out in California to meet local needs. But with the return of the south-eastern product to the California market, the western operations were abandoned.

Wood turpentine is chiefly used as a paint and varnish thinner, and has found its way very slowly into other commercial uses owing to its lack of uniformity, and the physiological effect it has on those working with it.

If wood turpentine is carefully distilled and a uniform product sold, it is reasonable to assume that the turpentine-using industries

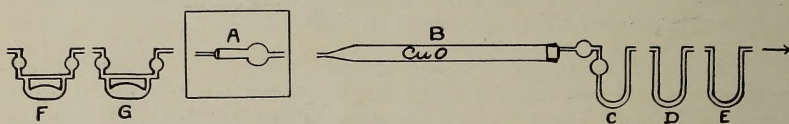


Fig. 1

will accept the product, in view of the present decreasing supply of the gum spirits.

The method used for determining the amount of volatile oil or turpentine was that devised by Gomberg¹, and a description of it will be given in detail.

A weighed amount of wood shavings (2-5 grms) is placed in the straight CaCl_2 tube A, shown in Fig. 1. The tube is connected on one side by means of a capillary tube connected with 2 wash bottles of special design, F and G, filled with KOH and concentrated H_2SO_4 which serves to free the air from CO_2 and moisture. The other end of the tube is connected to an ordinary combustion tube containing granulated CuO. The tube is drawn out as shown and the narrow portion loosely filled with asbestos wool. The connection is made glass to glass, so that the vapors of distillation do not come in contact with any rubber tubing. The end of the combustion tube is connected with a U tube, containing pumice stone saturated with concentrated H_2SO_4 and enough free acid left in the tube to just form a seal. Then follows a soda lime tube which is again followed by another tube containng pumice stone saturated with concentrated H_2SO_4 . The last tube is connected with an aspirator.

All connections having been made air tight, the connection

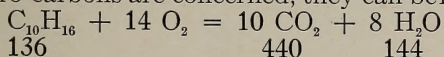
(1). Timber physics. Roth.

between the tube *A* and the tubes *F* and *G*, is shut off by means of a clamp, and the aspirator turned on. When the combustion tube has been heated to dull redness, the burner under the air bath is lit and the temperature raised to 110-120°C. The moisture in the tube escapes quite rapidly, carrying with it some turpentine oil. The capillary tube at the end of *A* practically checks any backward diffusion or any accumulation of condensed vapors. In about 15 minutes all the moisture appears at the forward end of the combustion tube. The clamp is now opened and a stream of air is passed through the whole apparatus while the temperature of the air bath is raised to 155-165°C, and kept at that point for about 45 minutes. Towards the end of the operation the temperature is raised to 175-185°C for ten minutes. The burner under the air bath is now turned off and air aspirated for twenty minutes longer. As the air bath and combustion furnace are in close contact, the whole length of the tube is kept at a temperature above the boiling point of turpentine oil. In this way a complete distillation is assured.

All the moisture is retained by *C* while the CO_2 is absorbed by the soda lime tube *d*, and any moisture from *D* collected in *E*. The gain in weight of *C* represents the moisture originally in the wood plus the water produced in the combustion of the hydro-carbons. The gain in weight in *D* and *E* represents the amount of CO_2 derived from the combustion of the volatile products.

The wood from the tube *A* is now transferred to an ordinary Soxhlet extraction apparatus, and exhausted with ether. The loss in weight represents the percentage of resin from the dried wood.

While the volatile oil may not be entirely pinene, but may contain other hydro-carbons of the same formula or belonging to the class of polyterpenes (C_5H_8)_{*n*}, it is clear that whichever they be, their percentage composition is alike in all; they all have *C* = 88.23%, *H* = 11.77%. Therefore, so far as the combustion of the volatile hydro-carbons are concerned, they can be represented by the equation



In other words 440 parts of CO_2 are derived from 136 parts of volatile terpenes.

$$440 : 136 = 1 : X \therefore X = 0.3091$$

For every part CO_2 obtained in combustion it represents 0.309 parts of volatile hydro-carbons, and similarly for every part CO_2 formed there is produced 0.327 parts H_2O .

$$440 : 144 = 1 : X \quad X = 0.327$$

Let weight of sample of wood = *W*.

Let weight of CO_2 obtained = W^1

Let weight of H_2O obtained = W^{11}

$W^1 \times 0.309 = T$ = amount volatile hydro-carbons.

$W^1 \times 0.327 = H^1$ = amount of H_2O corresponding to volatile hydro-carbons.

$W^{11} - H^1 = H$ = amount moisture in the wood.

$\frac{T}{W}$ = per cent. of T. $\frac{H}{W}$ = percentage of moisture.

Thus the moisture and the volatile hydro-carbons are obtained directly from the same sample.

Even if this method does not give the absolute amounts of turpentine yet it certainly gives results very near the truth, and what is more important under the same conditions, it gives constant values. Therefore by using exactly the same conditions in the analysis of different samples, results are obtained which can safely be used as indices of comparison of the relative amounts of volatile hydro-carbons in the samples under analysis.

The samples of wood for analysis, were in the case of the pinon pine, taken from average trees found in a pinon forest. A cross section was taken of two inches in thickness, at about two feet from the ground, and another taken about two feet from where the branches shoot out. The samples were analysed about one month after cutting.

In the case of the Jack pine, only one tree was sampled. This tree had been cut and exposed to the weather for about two years. When the samples were taken, the tree was covered with snow, which

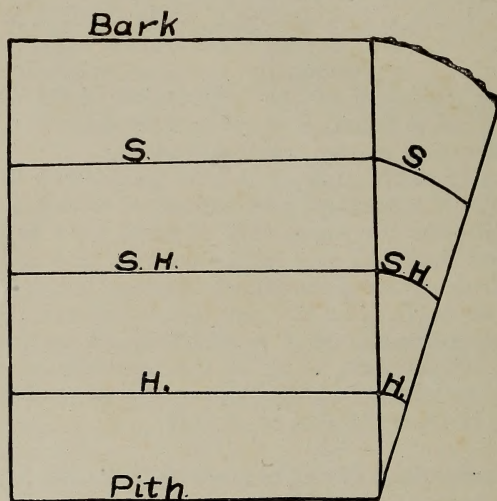


Fig. 2.

accounts for the large amount of moisture found. From the log of Jack pine three disks were taken, the first two feet from the butt, the second two feet from the first, and the third two feet from the second disk.

The material for analysis was prepared as follows: A radial section of the disk is selected, which is then cut transversely into three pieces, as shown in Fig. 2.

The first designated S, was cut about half way between the bark and the point where the sap and heartwood meet. The second S.H. at the junction of the heart and sapwood, and the third H. about half way into the heart wood. From the freshly cut transverse section enough shavings are taken to fill a weighing bottle, and from two to

five grains used for analysis, found by weighing the bottle before and after taking out the shavings.

The amount of moisture in the different samples does not seem to have any direct relation to the amount of oleoresin in these samples. Yet in the case of Jack pine, there seems to exist something like a relation between the two. In the case of the pinon pine there does

PINON PINE

Tree No.	Disk No.	Sample	% Moisture	% Terpene	% Resin Drywood	% Terpene Calc. to Drywood	Terpene — $\times 100$ Resin
1.	I	S	23.1	.75	6.45	.97	15.0
	I	SH	18.8	.40	5.64	.49	8.6
	I	H	20.1	.35	3.01	.44	14.6
	II	S	18.0	.60	7.72	.73	9.4
	II	SH	17.1	.38	4.88	.46	9.3
	II	H	16.3	.59	6.91	.70	10.2
2.	I	S	40.7	.33	5.92	.55	9.4
	I	SH	30.3	.32	4.87	.46	9.4
	I	H	22.0	.30	4.50	.38	8.6
	II	S	24.5	.24	4.93	.31	6.4
	II	SH	18.2	.26	5.34	.32	5.9
	II	H	16.1	.20	3.57	.24	6.3
3.	I	S	21.4	.57	7.56	.72	9.4
	I	SH	21.8	.39	5.62	.50	8.7
	I	H	16.4	1.01	8.90	1.21	13.6
	II	S	18.1	.39	5.07	.47	9.3
	II	SH	18.2	.69	5.32	.85	14.5
	II	H	15.6	1.14	6.87	1.35	19.3

JACK PINE

Disk No.	Sample	% Moisture	% Terpene	% Resin Drywood	% Terpene Calc. to Drywood	Terpene — $\times 100$ Resin
I	S	41.9	.64	6.28	1.10	17.5
I	SH	36.1	.69	6.47	1.08	16.6
I	H	38.2	.67	6.50	1.08	15.1
II	S	40.7	.66	6.86	1.11	16.1
II	SH	23.7	.80	7.02	1.05	14.9
II	H	34.3	1.38	8.91	2.07	23.2
III	S	57.4	.24	3.50	.56	16.1
III	SH	23.2	1.14	8.56	1.48	17.3
III	H	26.7	.83	7.14	1.15	16.1

not seem to be any relation whatsoever, even in the different parts of the same disk.

Only in the case of tree No. 3, in the pinon wood analysis, is there any great difference between the amount of volatile hydro-carbon, in the sapwood, and the heartwood, and in the analysis of Jack pine III., where the sample, III.S., was taken very close to the bark.

As the turpentine in the tree is a solution of resin in an oil, it follows that the richer the tree is in turpentine, the richer it should be in resin, and while in the case of Jack pine the greater the resin content the greater the amount of hydro-carbon, this relation does not show itself in any marked degree in the analysis of pinon pine, some trees showing nearly the same amount of resin, varying greatly in their turpentine content. There seems to be no constant relation between the different disks of the same tree, so far as the amount of resin is concerned.

In the table of analysis, by volatile hydro-carbon is meant only the oil which distills from wood up to 185°C , and would include the different forms of pinene, but would not include cadinene which boils at about 280°C . The latter, however, would be included in the resin content.

The percentage of moisture is only relative, the disks in all probability losing a certain amount after being cut. The figures only show the comparative amount of moisture retained since they were exposed to the same influences.

Many more analyses, excluding the possibility of chance selection, would have to be made before one could state positively, whether or not pinon pine is suitable for the manufacture of turpentine. However, it seems from the results obtained here, that the distillation of pinon pine cannot become a commercial possibility, at least until the Georgia pine and the Yellow pine of the South-western States have become extinct.

R. J. Spry, '10, is in British Columbia. He is engineer for the Eureka Mine at Granite.

J. P. Morgan, '10, is with J. J. MacKay & Co., construction engineers and surveyors, Hamilton, Ont.

G. C. Hoshal, '09, is in the employ of the Hydro Electric Power Commission at Windsor, Ont.

E. J. Brown, '08, is a member of the Canadian Westinghouse Co.'s staff in Toronto.

J. Armstrong, '95, is chief engineer of the Hudson Bay Railway.

H. V. Serson, '05, is superintendent of construction in New England for The Snare and Freist Co., engineers and contractors, New York.

A. R. Whitelaw, '09, who has been employed for the past two years as supervising engineer of construction of electric substations, and mill buildings for the firm of Smith, Kerry & Chase, Toronto has accepted a position with the Midland Construction Co., as assistant engineer on the Nealey Falls Power Development.

DIFFICULTIES IN CONSTRUCTION¹

By C. S. L. HERTZBERG, B.A Sc.²

It was my privilege a short time ago to address the Civil and Architectural Branch of your Society on methods of construction. On that occasion I recalled in some detail what I considered to be interesting features in the construction of a number of structures with which I had been connected.

Fig. 1 shows a section of the Canadian Pacific Railway reinforced concrete retaining wall on the south side of Front Street between Bathurst Street and Spadina Ave., Toronto. This wall protects the Canadian Pacific railway track which leads up to the company's new freight sheds on the old Government House property. The track parallels the wall on the south side of it, rising from an elevation of about twenty feet below Front Street at Bathurst Street to the street level at Spadina Ave., where it crosses Front Street on the level. The wall is about 2,000 feet long and varies in height from twenty-two feet at the Bathurst Street end to eight feet at the Spadina Ave. end. The lack of space on which to carry on construction work made the execution of the contract considerably more difficult than would otherwise have been the case. The strip owned by the Canadian Pacific Railway was about fourteen feet wide and was all on a steep slope from the elevation of Front Street on the immediate north to that of the Grand Trunk yard immediately south. The wall itself was built with the face on the south line of Front Street. The base of the wall at the deepest part projects under the track of the Toronto Railway Company which runs along the south side of Front Street. From this it will be seen that there was no room to operate on the north of the wall excavation, while, to the south, the ground sloped sharply down to the Grand Trunk tracks.

The material to be excavated was the very hard blue clay found in that locality. As there was in the neighborhood of 10,000 cubic yards of excavation to be done, it was decided to use a steam excavator for the deepest sections while the shallower part of the trench was taken out by hand labor.

The Toronto Railway Company was approached with a view to getting them to abandon their southerly track for certain hours of the day, in order to allow wagons to be placed on the track for the removal of the excavation. The railway company, however, would not consider any such plan, and a temporary plank roadway had to be built out over the bank to allow teams to approach the excavator. Here they were loaded from the Harris orange-peel machine which straddled the trench on a temporary track. The machine dug a trench about ten feet wide at the rate of about one hundred and twenty cubic yards per day of ten hours, under the most favorable conditions.

The temporary roadway was so narrow that several teams

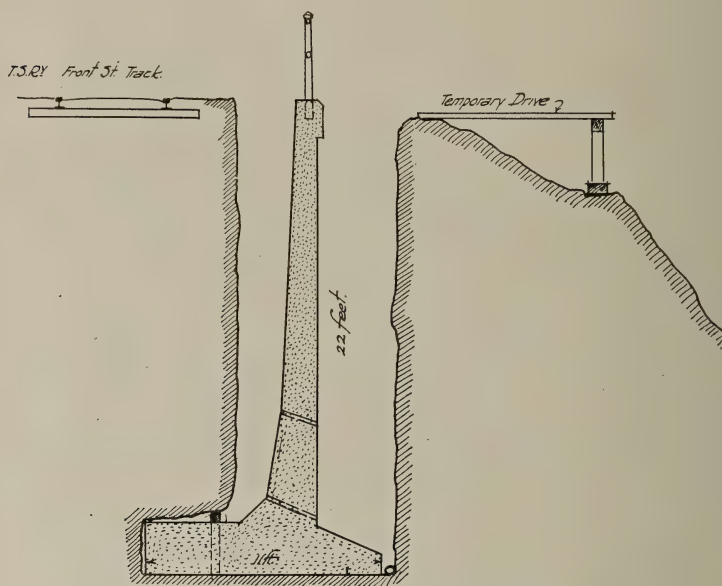
¹ Paper read before the Engineering Society.

² James, Loudon and Hertzberg, Consulting Engineers.

fell down the bank to the Grand Trunk tracks and one horse slipped out of his harness and fell twenty feet to the bottom of the excavation. This horse reported for duty next day after having walked out on a ramp built for the occasion.

Fortunately the blue clay was very stiff and stood up well with comparatively little shoring, until the excavation was made for the toe of the wall, which projected under Front Street and under the south rail of the Toronto Railway tracks. The bottom of the trench was prepared to receive the concrete before the undermining for the toe was commenced.

The undermining extended inwards about five feet from the face of the trench at the deepest part. As this undermining left



22 ft. SECTION of RETAINING WALL

Fig. 1.

an unsupported overhang of earth about twenty feet deep, along which street cars were continuously running, great care had to be taken in carrying on operations. This work was done in the early part of last summer during which we had an unusual amount of rain, increasing the danger from cave-ins. The undermining was done in sections about twelve feet in length, after which the base was immediately poured and the concrete tamped in under the overhanging clay. A whaling piece of timber, six inches square was also placed under the edge of the overhang and supported with uprights. No attempt was made to recover these timbers. The framework for the shaft of the wall was then erected to about six feet above the top of the footing and the cross braces were removed to this

elevation. The wall was then poured to this height. After this had been allowed two days in which to set, and while the next six feet of forms were being erected, the bottom three or four feet of the north face was stripped and painted with tar and asphalt. Then a backing of twelve inches of head size stone was placed against the wall and the excavation was filled in to this level at the back of the wall.

This process was continued until the level of the underside of the coping was reached. For the coping, special forms were made in sections which were shifted for each section. By pouring the coping last it was possible to line it in independently of the face of the wall and thus any irregularities were overcome. It may be of interest to state that the average cost of this wall ran about \$25.00 per lineal foot, including excavation, backfill and a pipe railing along the top.

We are fortunate in Toronto in having a good solid subsoil on which to rest our foundations. In Winnipeg some of the greatest obstacles encountered in construction work are due to the difficulty of obtaining good foundations.

In no part of Winnipeg is it customary to stress the soil to more than two tons per square foot, and even this is too heavy a stress under conditions where there is any likelihood of unequal loading. The clay there is in inclined strata. When water soaks through the soil these strata will slip past each other, if the loading is at all excessive or unequal. Especially is this the case along the banks of the rivers. These banks are continually slipping into the rivers and being carried away by the current.

In one particular case there was a bridge erected over the Seine River (a small tributary of the Red). This bridge was built in such a position that the course of the stream was changed and turned sharply just before flowing through the bridge. This appeared to upset the "status quo" of the forces acting, and the result was that about an acre of ground adjoining the river sank about ten feet and the bed of the river was heaved up forming an island in the middle of the stream. The movement began to bring the bridge abutments together and a great deal of trouble was taken to endeavour to keep the structure from collapsing. Structural steel and heavy reinforced concrete braces were put across from one abutment to the other near the foundations. These, however, were buckled up and it was finally decided to remedy the trouble by dynamite. This was done and a complete new structure was erected. Fig. 2, shows this new design in elevation. It will be noted that this design calls for very heavy arch with large solid abutments on piles and an invert across the bottom. It was the object, in getting out this design, to plan a culvert that would withstand so much pressure that if the country side shifted again it would carry the arch with it and not break it. The wing walls could not be constructed on this plan, but their bases were connected by a concrete apron ending in a heavy concrete strut which served the purpose of a brace as well as a curtain to prevent scouring of the current. The construction

was carried on in very severe weather and under great difficulties. I understand that the wing walls have been forced in by the pressure from the banks while the bridge itself is still in good condition.

I might enumerate a great many more examples of the physical difficulties with which a contractor may have, unexpectedly to contend with, but some of his largest stumbling blocks are not physical. There is a picture which is supposed to depict a contractor who has just been notified of the fact that he is the "successful bidder." He has a very dejected look and is endeavoring to recollect what necessary items he has failed to include in his tender. It is very often the case that, in competitive tendering, a contractor's only chance of getting the work is by leaving that "something" out of his calculations. This is a practice that is neither profitable for

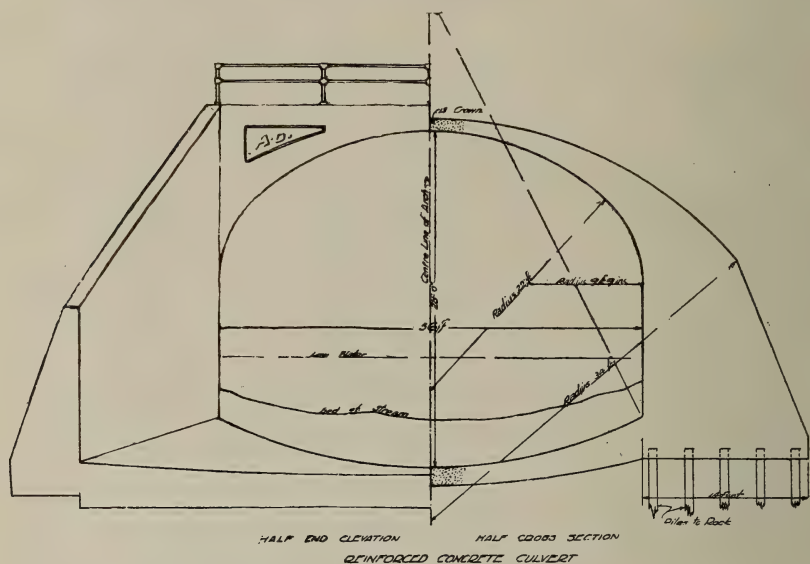


Fig. 2.

the man who gets the contract, nor for the others whose tenders were not accepted. Then the "successful bidder" usually has to sign a contract which is a distinctly arbitrary document. The specifications generally state that if any dispute shall arise about the interpretation of the plans or specifications the dispute shall be settled by the architect or engineer, which is frequently equivalent to assuring all concerned that any dispute shall be settled in favor of the owner and at the cost of the contractor. This is manifestly unfair, but seemingly inevitable, and it therefore behooves us, as engineers and architects, to make our plans and specifications so explicit and comprehensive that no reasonable dispute is likely to arise in the interpretation of them.

FIREPROOF BUILDING CONSTRUCTION

By G. M. Cook, B.A.Sc.

A discussion of this subject might well be preceded by a consideration of the statistics bearing upon the enormous fire waste which America experiences annually. Associated with it a resume might be given of the frame building era. Until recently the abundance of timber has appealed to the builder, as has also its adaptability to most varied conditions and the speed and ease with which it may be erected. But the type of construction finds its name unpleasantly connected with fire waste, which is the greatest of its undesirable tendencies. Moreover, the increased cost of timber, due to the growing scarcity, coupled with the introduction of low priced fireproof materials, is having no small effect upon the statistics concerning destruction by conflagration.

Following closely the study of the design and equipment of a proposed fireproof building are the problems of construction. As far as construction alone is concerned, the definition may be applied that a fireproof building is one which may have its contents cremated without being seriously impaired structurally.

With this as a basis, there are essentially only two kinds of buildings which can be made to fulfil the requirements, reinforced concrete and fireproof steel. It is quite impossible to lay down a general law and say that one is better than the other, and should be used exclusively. Each has its particular adaptability and it is only by minute and careful study of each particular case that the correct choice may be made. It might, therefore, be beneficial to look at the various features of each which appeal to the builder.

The cost is worthy of first consideration, as it is in most cases the deciding factor. Only general figures are significant on account of the greater variation in the cost of building materials and labor in different localities.

In most cases reinforced concrete will be cheaper than steel construction. This is due to the availability, in most localities, of the materials of which concrete is composed. Sand and gravel are plentiful, and numerous cement mills are spread all over the country. The wooden forms used in concrete construction have been the largest item of expense, so metal forms which can be used over and over have been introduced. The average cost of a concrete building is estimated at 8.5 cents per cubic foot. This includes plumbing, but not lighting or mechanical plant.

Tyrrell states that for live loads of 150 pounds per square foot of floor area and over, concrete will be cheaper than steel from 5 to 20 per cent. For lighter loads the costs of the two systems will be about the same and for very light loads steel will be slightly cheaper.

When the design of a concrete building is complete, construction may proceed almost at once. The materials necessary for the concrete are readily obtainable and the kind of steel used is, as a rule, kept in stock in any large town. On the other hand, structural

steel has to be ordered from the mills and then must be fabricated in the structural shops. This often causes long delays and may be the cause of considerable inconvenience.

It is difficult to erect concrete work in freezing weather. Thus, when a building has to be rushed up in the winter, in our latitude, steel usually has the preference.

Concrete beams and girders are, of course, much deeper than those of steel for the same loads. These deep beams may make necessary a greater story height to obtain a given head room. Again, the floor area taken up by columns in a concrete building is much greater than that occupied by steel ones.

The question of permanency cannot be discussed in this paper. Both systems are comparatively new and it is a question of how long either will last. One, if properly designed and honestly put up, is probably as stable as the other. Engineers, contractors and owners, are every day displaying their confidence in both forms of construction.

A point which is often worthy of consideration is the fact that the expenditure on a concrete building is nearly all local. The materials for the concrete are, as a rule, available in the vicinity of the building and the labor required may be unskilled. A steel building on the other hand must be put up by experts and the steel in most cases is manufactured and fabricated far from the scene of erection.

These considerations apply, of course, only to buildings of moderate dimensions. There is a practical limit to the height to which a reinforced concrete building may be erected. Capt. Sewell of the U. S. Army, reporting on the San Francisco disaster places this limit at 125 feet. The revised San Francisco building code prohibits the exclusive use of reinforced concrete in buildings over 102 feet in height. The difficulty in tall reinforced concrete buildings is with the sway bracing. The size of the columns in the lower storeys of a tall concrete building is also an objectional feature.

Materials for Construction

It was at one time thought that, if a building were made of non-combustible materials, it would be fireproof. This appears to be so and would be practically true if all the contents of the building and the surrounding structures were also incombustible. The function of most buildings, however, is to house combustible materials. At the present stage of our development nearly all our so-called fireproof buildings are surrounded by frame or other non-fireproof structures.

The committee of the American Society of Civil Engineers on the effect of the fire on building materials in San Francisco made the following comments: "All materials were destroyed when directly exposed to the fire for any length of time—brick, terra cotta, granite, concrete—all failed."

"The logical deduction from the statement that all material were destroyed is the conclusion that all structural parts of a building

of whatever materials constructed must be protected by another material which will be a more or less complete loss in a fire."

It may be noted that the same report later states that, "Where afforded any reasonable protection, the steel was uninjured and so the committee feel warranted in stating that it is possible to protect such a frame so that it will pass uninjured through a fire which consumes all the parts that can burn." ¹

This was also the experience in Baltimore, where, though fireproofing was in many cases destroyed, the structural integrity of the building was little impaired.

The highest temperatures reached in fires are from 1,600 degrees F. to 1,800 or even 2,000 degrees. In Baltimore the highest temperatures reached were from 1,500 degrees to 1,800 degrees. Glass was melted, but brass was not. In the Parker building after the fire, copper wire which had been fused, was found. From this it was decided that the temperature was above 1,800 degrees for considerable periods in several storeys.

An ideal fireproofing material would have the following properties: (1) Incombustibility, (2) Ability to withstand any molecular change when heated, (3) Reasonably poor conductivity of heat; and, (4) Capability of taking any structural load required.

Brick

Hard burned brick is the best fireproofing material known. It fulfils all the requirements. When in position it is very little affected by temperature stresses on account of the small size of the individual brick and the numerous joints.

It is not used a great deal on account of its weight and its cost.

Terra Cotta

This material was first introduced to take the place of brick on account of its decreased weight. There are now three kinds in use—dense, porous and semi-porous terra cotta.

Dense terra cotta is made of pure clay burned at a temperature of about 2,200 degrees F. under pressure. The resulting product possesses a dense texture and considerable crushing strength. It is brittle and unreliable under shocks.

Porous terra cotta is a better fire-resisting material than the dense variety. It is made by mixing 25 or 30% of sawdust or cut straw with the clay before burning. During the burning all this material is consumed and the tile is left with a very porous texture. It is so soft that it can be cut with a saw, and nails and screws can be driven into it.

Semi-porous tile is made by mixing about 20 per cent. of coal dust with the clay before burning. This is consumed in the kiln and helps bake the tile. The result is slightly less porous than when sawdust is used. It cannot be cut like porous tile.

Terra cotta is incombustible, is a reasonably poor conductor of heat and undergoes no molecular change when heated. Norton

1. Trans. A. S. C. E. Dec. '07, p. 243

states that after the Baltimore fire the terra cotta had a good ring when struck and so was unchanged chemically.¹

As commercially applied, terra cotta is not very satisfactory. Where this material was used in Baltimore it served its purpose in that it preserved the integrity of the steel, but it had not sufficient strength to save itself. This was due to a false sense of economy which caused the webs of the tile to be made too thin.

The material is a remarkably poor conductor of heat. Thus, during a fire, the outer face of the tile becomes red hot while the inner webs being surrounded by air spaces remain comparatively cool. The temperature stresses thus set up have sometimes caused the outer face to shear off where it joins the webs perpendicular to it. It has been noted that where plaster applied to the tile retained its position, the outer face did not fall off. This shows the need and efficiency of thicker webs.

Sewell considers that, if terra cotta were made of good refractory clay with webs at least $1\frac{1}{2}$ inches thick, it would be equal to the best brick as a fireproofing material.

The air space in the tile is of little use when the webs are too thin. The outer web should be of sufficient thickness to take up almost the entire change of temperature, i. e., when the outside is red hot, the inside should be at normal temperature.

Concrete

Concrete has of late years become very popular as a fireproofing material. It does not so nearly as terra cotta fulfil the requirements of an ideal material, but its deficiencies are more than made up by the manner in which it may be applied.

As is well known, concrete contains a certain amount of water which is taken up when the material sets and forms an integral part of the concrete. When the concrete is heated, this water is driven off. The material which is left, is amorphous and has little or no strength. This dehydration begins at 500 degrees F., and is completed at 900 degrees F.²

It takes considerable heat to vaporize the water and this keeps the temperature down. Moreover, the material which is left, though it has little strength, is a poor conductor of heat and it will retain its position unless disturbed. The maximum depth to which concrete will burn off is one inch to $1\frac{1}{2}$ inches. In a concrete building in Baltimore the concrete was destroyed to a depth from one-quarter to three-quarters inches.

As stone suffers from dehydration when heated, it is not so good an aggregate as those materials which contain no water of crystallization. For this reason trap rock, broken brick and cinders may be used.

Cinder concrete, while a first-class fireproofing material, is unreliable and should not be used structurally. The Structural Association of San Francisco examined the cinder concrete floors

(1) Eng. News, June 2nd, '04.

(2) Report Joint Com. Eng. Cont., Sept. 1st, '09.

in buildings taken down after the fire. They found that the corrosive action of the cinders had been such that "it is doubtful if the floors would have supported their loads for three more years." Norton made several hundred experiments and decided that the corrosion is not, as it is commonly supposed, due to sulphur in the cinders but to a too dry mixture. There has been a considerable amount of discussion on this point by friends of cinder concrete, but its use is now considered poor practice. It is easy enough to specify that only "clean boiler cinders" shall be used, but not so easy to see that the specification is carried out. The use of cinders should be especially avoided in slabs where the reinforcement consists of fine mesh material.

The following results were obtained at the Massachusetts Institute of Technology by Prof. Norton.¹ The co-efficient of conductivity is in calories, per degree centigrade, per square centimeter, per minute.

Material	Coefficient of Conductivity
Stone concrete 1-2-5 mix	.00216
Stone concrete 1-2-4 mix	.0021 to .0029
Cinder concrete	.00081

The figures indicate that cinder concrete is a much poorer conductor of heat than stone concrete.

Iron and Steel

Steel and cast iron, being incombustible, were considered fireproof, at one time, and so were freely exposed. That nothing is farther from the truth was soon discovered. In the Young building in San Francisco the reinforcement of the concrete beams consisted of a flat bar of iron hooked over the steel girders and with the concrete built up on top of it. After the fire nearly all these beams had collapsed and the remainder were badly deformed.

Steel and cast iron lose their rigidity and consequently their ability to support loads at comparatively low temperatures. Steel columns under load fail at about 1150 degrees F. and cast iron columns at 1300 degrees F. Much higher temperatures than these are, of course, reached in fires.

The problem of adequately and at the same time economically, protecting these materials is the chief part of the science of fireproofing.

Fireproofing of Columns

The adequate protection of columns is the most important problem of fireproofing. If a floor fails, the damage is confined to that particular panel and in the case of a beam failing the damage may be rectified by replacing the injured member and a small part of floor which it supported. When a column fails, however, the damage is liable to be much greater. If it is situated in one of the lower storeys, not only is part of the floor above lost, but the damage may extend from floor to floor, even up to the roof.

In the fire which followed the San Francisco earthquake a great

(1) Proc. N. A. C. U., 1911.

number of columns which were improperly protected, collapsed. In the Fairmount Hotel, which was under construction and so contained little combustible material, 25 per cent. of the columns failed. They were protected by spreading the metal lathing of the partitions out around the columns and applying a coat of plaster.

It has been a common practice to cover a column with wire lath and hard plaster and call it fireproofed. In a moderate fire the plaster calcines and, when water is applied, washes away. Plaster of Paris compositions are especially poor as this material undergoes molecular change at very ordinary temperatures.

When two layers of metal lath covered with plaster are applied, the probability of the columns being exposed is greatly reduced. This system is fairly satisfactory as was shown in San Francisco.

Another common practice has been to build up around the column a wall of terra cotta separated from the steel by an air space. This was done on the supposition that the air space would increase the efficiency of the fireproofing in keeping down the temperature of the column. This is "a snare and a delusion." Unless the tile is supported by the column, it is liable to fall down and expose it. In Baltimore the columns were exposed in many cases but rarely failed.

Terra cotta, when used to protect columns, should be built as close as possible to the steel. The intervening space should be filled with concrete as this not only supports the tile but preserves the metal from corrosion. Metal mesh material, if wrapped around the fireproofing, forms a support for the plaster and also helps to keep the tile in place.

Red brick set in Portland cement mortar is the best protection for columns. It should be laid flat, i. e., 4 inches thick. It is not generally used on account of its high cost and great weight.

Concrete at least four inches thick and held in place by wire fabric is considered equal to first class brickwork. There appears to be no objection to using cinder concrete for this purpose. It has to carry only its own weight and the steel can be protected from corrosion by first applying a coat of Portland cement paint. It would protect the column much better than stone concrete.

It is necessary, since concrete is affected by heat, to protect reinforced concrete columns. Terra cotta may be used for this purpose but it appears more rational to make the column a little larger than it is structurally necessary. The surplus material increases the factor of safety of the column when this is done.

The National Board of Fire Underwriters specify that all steel shall be protected by a thickness of concrete four times the thickness of the steel but not less than one inch or more than four inches. These requirements are considered somewhat too severe. Two or three inches of concrete will, without doubt, in most cases protect the steel sufficiently. All of this does not, of course, have to be surplus material. It would be enough to add one inch to figured diameter of the column, thus leaving one-half inch all around which could be burned off. Calcined material drops off most readily at exposed corners. For this reason it is better to have the corners rounded.

The question of fireproofing columns or, indeed, any member, is largely one of degree. In a warehouse where large quantities of combustible materials are to be stored more protection is necessary than in an office building where the only burnable materials consist of furniture and a little trim. In San Francisco a large percentage of the column failures took place in the basements. This was due to the high temperatures caused by the damping effect of the debris. A column, then, in the basement should be more carefully protected than one in the upper storeys of the same building.

The placing of pipes inside the column fireproofing should not be permitted. This on first sight appears to be a convenient way to get the pipes out of sight, but it is often responsible for the failure of the protecting material.

When just enough fireproofing is supplied for the column, any pipes which are encased must of necessity must be comparatively close to the surface. In a hot fire these pipes will expand and cause the fireproofing to break up. It is not objectionable to place the pipes in an adjoining "pipe chamber" properly disconnected from the column.

Fireproof Floors

The brick arch was one of the earliest attempts at fireproof floor construction. It usually consisted of a single rib of brick sprung between the lower flanges of I-beams spaced four or five feet centres. For very heavy loads the bricks were placed on end thus giving an 8 in. rib. The space above the brickwork was filled with light concrete to the floor level.

The corrugated iron arch was another early form. It consisted of a sheet of corrugated iron sprung between I-beams spaced from six to ten feet centres. The haunches of this arch were also filled with concrete.

Neither of these types were really fireproof as they leave the lower flanges of the supporting beams exposed. This was sometimes provided for in the case of the brick arch, by using heavy terra cotta skewers. These types are no longer used on account of their great dead weight, which usually approximated 75 lbs. per sq. ft.

Terra cotta arches were next introduced. They made a great reduction in the dead loads and made the modern tall buildings possible. The early arches were entirely of side construction and the beam soffits were left unprotected. It is an interesting fact that terra cotta was first applied to the lower flanges of the beams, not to protect the steel but to save the plaster. When this was applied directly to the metal, unequal condensation of moisture caused a dark streak to mark the position of the beam.

The early forms were somewhat crude, but eventually the modern forms were developed. There are now two general types of arch, flat and segmental. The flat arches are of three general types, side, end and combination, construction.

The side construction arch was the earliest form. In it the voids run parallel to the supporting beams. Little material is located in the plane of greatest stress, and hence is practically inert.

In end construction the voids run from beam to beam. Thus practically all the material is available for arching action and a much stronger floor is the result. In this construction it is difficult to get an even bearing between the individual tiles and between the skewbacks and the webs of I-beams. Moreover, as has been pointed out, the exposed web of terra cotta blocks is liable to be cracked off by unequal expansion during a fire. If this happens to an end construction skew, the web of the beam will be exposed. The web of the supporting beam is not protected from corrosion as it is with side construction.

It was to combine the good qualities of both these types that combination construction was devised. In it the skews and often the key are made of side construction while the fillers are of end construction. It is necessary, of course, to make the side construction features stronger than usual in order that the full strength of the fillers may be developed.

It is preferable to use an arch the full depth of the supporting beams. This saves in concrete fill and thus keeps down the dead load.

The segmental arch is, as its name implies, circular in form. It is stronger than the flat arch and so the depth of block for a given floor load is less. This reduces the cost, but in office buildings the panelled effect of the ceilings is objectional. If side construction is used in this type of arch, the rise of the arch may be varied by the thickness of the mortar joint either at the top or the bottom. This cannot be done with end construction.

In constructing terra cotta arches Portland cement mortar is used. Care must be taken to wet the tile before placing, or the porous terra cotta will take water from the grout and leave it without strength. If porous tile is wet in cold weather, it is liable to be cracked by freezing.

It is claimed by the manufacturers that the dead air space in the tile makes a terra cotta floor almost sound proof. This is of considerable importance in some classes of buildings.

The tiles fill the whole space between the beams and thus add considerably to the lateral stiffness of the building. Terra cotta floors are much better in this respect than concrete slabs which rest on top of the beams.

Concrete floors require a good deal of centering, and this, when in position, interferes with other trades. In the Pittsburg Terminal Warehouse, the forms for the terra cotta floors were suspended from the steel beams. They do not, of course, require to remain in place as long as the forms for concrete work.

The dead weight of terra cotta floors is greater than that of concrete on account of the concrete fill. This, of course, increases the cost of other parts of the building. In some places it is difficult to obtain tile, while the materials which go into concrete are plentiful in most localities.

Terra cotta, as applied to floors, is open to the same objection as when used in other places, i.e., the webs are made too thin. In Baltimore practically all the floors were damaged by having the lower

webs drop off. The loss there was 50% on all floors of this type. The same thing took place in San Francisco.

Concrete floors are of two general types, slabs and segmental arches.

The slabs consist of a layer of concrete containing steel which takes all the tensile stresses. The steel is of necessity placed close to the lower surface of the slabs. In order that the steel may not be softened by the heat in a fire, it must be covered with a certain amount of material which adds nothing directly to the strength of the slabs. The National Association of Cement Users require the metal in slabs to be protected by 1 in. of concrete.

In the segmental concrete arch all the concrete is in bearing and the floor does not rely for its strength on metal close to the surface. For this reason the segmental arch is more desirable as a fire-resisting floor than the flat slab.

To place segmental concrete floors, permanent metal forms are now used. The form consists of some stiffened metal fabric, such as Hy-rib. The plaster is applied directly to the underside of the metal. Floors so constructed dry out rapidly and very little extra form work is needed.

Concrete floors have behaved creditably in many actual fires. In the Bank of Commerce building in Baltimore, all the combustible material was consumed. The door and window frames were all burned out, but the concrete slabs were apparently uninjured.

Terra cotta and concrete have in some cases been combined to form floors. In one floor of this type the terra cotta blocks merely act as permanent forms between little reinforced concrete joists. This floor has all the advantages and disadvantages of terra cotta floors. It is suitable for very long spans and in construction requires little form work.

In the Johnson floor, which is patented by the National Fireproof Company, the tile act in compression. Wire fabric in a thin layer of concrete below the tile takes up the tensile stresses.

When the floor construction gives an undesirable panelled effect to the ceiling below, a suspended ceiling is sometimes used. This consists, as a rule, of metal lath supported on light channels and covered with a coat of plaster. In San Francisco these false ceilings were very effective in protecting the floors from the fire. They were usually destroyed themselves, however.

It is very necessary to provide for the drainage of fireproof floors. If this is not done water is liable to soak through and damage the plaster on the ceiling below.

A great many forms of floor have been tested for the New York City building department. The main features of the standard test are as follows¹: The floor to be tested forms the roof of the test structure and the fire is built on a grate from 9.5 ft. to 10 ft. below it. The floor is tested within forty days of the time of construction. The dimensions of the panel tested are to be at least 14 ft. x span. The temperature measured at various specified places is to average 1,700 degrees F for four hours. It is obtained by burning wood. At the end of four hours water under 60 lbs. pressure is to be dischar-

(1) Trans. A.S.T.M., Vol. VI, 1906.

ged through a 1 1-8 in. nozzle against the under side of the floor for ten minutes. The top of the floor is then to be flooded under low pressure.

During the test the floor must sustain a load of 150 lbs. per sq. ft. and, after the water has been applied, a load of 600 lbs. per sq. ft.

The requirements are that no fire or water may pass through the floor during the test and the permanent deflection must not be greater than 1-8 inches for each foot of span.

A great majority of the floors tested up to 1906 successfully withstood the test.

Beams and Girders

When beams support the floor directly, they are, as a rule, protected by the material of which the floor is composed.

When concrete is used for this purpose, some kind of wire fabric should be provided to hold it in place. The bond between the concrete and the steel beam will be very poor. When mesh material is securely bonded into the side protection, it will hold the concrete in position through a very hot fire.

The protection of girders should be built up independently of the floors. If this is done, the girder is not exposed should the floor fail.

Concrete beams and girders should have 1½ ins. outside any metal reinforcement. The reinforcement in the beams of the Johnson Building was only protected by 1 in. of concrete, and the beams failed.

Partitions

As has been already pointed out, it is necessary to divide a floor into as many units as convenient so as to protect as large a percentage of its contents as possible from a fire which starts among the rest. To carry out this purpose, the partitions must be capable of withstanding fire.

A common partition in the past has consisted of metal lath supported on light channels and covered with a coat of hard plaster. In a fire the plaster quickly disintegrates, and allows the fire to break through. Portland cement plaster is more efficient, but must be fairly thick to effect its purpose.

Terra cotta tile is often built up to form a partition. As has been already pointed out, the webs of commercial tile are too thin and, if they drop off during a fire, the whole partition is likely to fail.

In the Baltimore fire none of the light partitions in common use was a success. The loss in partitions in that fire was 85%.

Concrete partitions, while they could without doubt be so constructed as to be fireproof, are too expensive for common use. Moreover, if it is desirable to rearrange a floor, the concrete partitions are not easily cut into or moved.

Exterior Walls

The nature of a building's exterior walls is usually determined by the architect. The appearance of the walls is often the main consideration and so the engineer has, as a rule, very little to say about them. It would not be out of place, however, to consider the advantages and disadvantages of various forms.

Natural stones are very popular for this purpose on account of their fine appearance. They are, however, very poor resisters of fire. This is due to the fact that nearly all building stones are crystalline and, when heated, give up the water they contain. Granite is especially poor. In San Francisco it suffered more than any other stone. Marble calcined but sandstone suffered somewhat less.

Architectural terra cotta fared badly in San Francisco. This was due to the fact that the sections were too thin and the material could not withstand the expansive stresses set up.

Brick is perhaps the best material for outside walls from a fire-resisting standpoint. It is also comparatively cheap.

Concrete walls have been tried but have not met with general favor. They are difficult to put in place on account of the form work and their appearance is not pleasing.

Necessity for Good Construction

"The results at Baltimore and San Francisco did not by any means indicate that either hollow tile or concrete is altogether a failure or altogether a success. Both fires indicated very clearly that commercial methods of applying both materials are inadequate, both also indicated very clearly that successful results can be obtained with both materials." ¹

A little good workmanship would have saved much damage in Baltimore, even without any improvement in type or design. After the fire it was found that the brick walls of a so-called fireproof hotel consisted of an out and an inner layer of good brick while the space between was filled with brickbats, broken tile and refuse.

It is far worse to call a building fireproof, when it is poorly constructed, than to erect a non-fireproof one under its true colors. Architects are prone to pass poor work to avoid delaying the completion of a job, and advantage is taken of this by the contractors.

An analysis of the cost of fireproof buildings in Baltimore showed that the cost of the actual building was but a small part of the total. The steel frame and fireproofing cost only 27% of the whole, while the remaining 73% was made up of such items as ornamental stonework, decorations, finish, plumbing, and mechanical plant. In trying to effect a saving on the fireproofing which costs about 5% of the whole, all these items which make up by far the greater part of the value of the building are endangered.

D. D. MacAlpine, '09, until recently a salesman for the Canadian General Electric Co., Toronto office, is now in the employ of the Riordan Paper and Pulp Co. at Hawkesbury, Ont., as engineer.

(1) Sewell Eng. Rec., June 11th, '07, p. 699.

OBITUARY

N. R. ADAMS, '16.

We sadly record the death of one of the prominent members of class '16 in Mechanical Engineering. Mr. Adams had no sooner engaged upon his summer's work than his father received the sad news of his death by drowning in Ross Lake, Manitoba. Having just completed his first year he had engaged with the Grand Trunk Pacific Railway Company in the shops at Graham, Manitoba, when the fatal accident occurred.

Mr. Adams was 19 years of age. He will long be remembered by his class mates as a man of very promising ability. He was elected to the office of recording secretary of the Engineering Society for 1913-14, and had just begun to fill most efficiently the trust confided in him in this capacity by his colleagues, when his career was so unexpectedly terminated.

To his parents and intimate friends APPLIED SCIENCE extends its sympathy and regret.

FINANCIAL REPORT, 1912-13

The President and Members,
The Engineering Society,
University of Toronto.

Gentlemen:

We beg to present herewith the financial report of the University of Toronto Engineering Society for the year ending March 31st, 1913.

It will be observed that a decided reduction in the surplus of the Society has been experienced since the presentation of the last report. A small part of this difference is due to a few accounts payable, which had not been presented, and were unaccounted for, in the last annual statement.

That this decrease in surplus is accompanied by an increase of more than 50% in the business transacted by the Society during the year, is an indication of the strenuous endeavors on the part of your executive, to minimize it as much as possible. This is further exemplified by a consideration of the merchandise sales per student in last and the previous year. In 1911-12, supplies to the value of \$8,108.34 were bought by 798 students, or \$10.16 per student. In 1912-13, the sales amounted to \$12,497.66, for 680 students, or \$18.38 per student, an increase of over 80% per capita, when based upon student attendance. This was accomplished without increase in the price of any of the supplies carried.

The decrease in surplus, notwithstanding this extension of business, is due to the fact that approximately 80% of the sales during the first term is transacted with first year men, and that the enrolment of first year men last year was only 57% of the average of the three

preceding years. Such a decrease was quite unexpected, and the supplies which would have normally been disposed of early in the term either appear in our inventory, valued at cost, or through the courtesy of our supply houses, were reverted to them.

Finally, the idea was not entertained of imposing upon the members of the Society any advance in prices to compensate for the decreased market, while the surplus left by the previous executive was sufficient to withstand the deficit.

Respectfully submitted,

H. R. MACKENZIE, Treasurer.

H. IRWIN, Manager.

UNIVERSITY OF TORONTO CLUB OF NEW YORK

At the 11th Annual Meeting of the University of Toronto Club of New York, held in the Engineers' Club, 32 West 40th Street, on Thursday, April 24th, the following gentlemen were elected:

For Honorary Membership, Dean C. K. Clarke; for President, Thomas H. Alison, S. P. S., '92; for Vice-President, J. P. Ogden, M.D., '88; for Vice-President, John Angus MacVannel, B.A., '93; for Vice-President, F. W. Harrison, S. P. S., '05; Secretary-Treasurer for 5th year, T. Kennard Thomson, S. P. S., '86, 50 Church St., New York City; Membership Committee for three years, A. Le Roy Chipman, B.A., '02.

The election was preceded by a good dinner and followed by many pleasant discussions and chats.

Every University of Toronto man, who has had occasion to visit New York, has found the hospitality extended to him by members of this Club most delightful. Since its beginning, the Club has had a steady healthy growth. Its frequent meetings and enthusiastic officers have shown the inevitable result among graduates who reside there. With a fee of only two dollars per year, every former student of this University should enroll as a member and associate himself with its activities.

Prominent among its members, as an ex-president, and as a secretary-treasurer, we note Mr. T. Kennard Thomson, '86. He was secretary-treasurer of the Organization Committee of the Engineering Society in the year 1885. We are merely mentioning it.

Open to Graduates

The general secretary of the Engineering Society and managing editor of APPLIED SCIENCE, is leaving to assume the editorship of THE CANADIAN ENGINEER. The vacancy caused by his withdrawal from the office he has held for the past three years will be filled before the opening of the fall term.

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AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

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EDITORIAL

Elsewhere in this issue appears, in extracted form, a report of the work of one of our research scholars. It deals with one of the subjects selected for research last year, and is published in part only.

Its appearance at this early date is perhaps an indication that the investigation into the commercial value of resinous oils in pinon and jack pine did not produce the desired result. Until the present sources of supply are exhausted, or impaired to a much greater degree at least, the above woods need not be looked to for turpentine and resin in sufficient quantities to compete with the present available supply elsewhere.

The finding of this result did not take up the entire time which Mr. Shaw had at his disposal. He devoted considerable study to the problem of converting non-drying oils into drying oils. The solution of this is of most vital importance to the chemical industry. Natural-

ly it is a problem not susceptible to easy discovery. Although many methods, each pointing to a likely result, were investigated they were unsatisfactory commercially. The work could not be finished owing to lack of time and scarcity of sufficiently pure chemical agents. Nevertheless results were obtained that were most favorable in some cases, but the degree of drying qualities in the resulting product, which would secure its passage from experimental into industrial use, was lacking.

Mr. Shaw has left to accept a position in Wyoming on work of a nature similar to that in which he has been engaged as a research fellow in the University of Toronto. He carries away a well-earned confidence in his own ability, a consciousness that diligence and perseverance along suitable lines will solve problems most difficult of solution, and a training in research that fits him for the study of the many intricacies that form a part of his chosen profession or are closely allied to it.

THE ENGINEERING ALUMNI ASSOCIATION

The Annual Dinner of Toronto Branch

The annual meeting was held at McConkey's on Tuesday, March 25th, at 6.30 p.m. Some fifty graduates were in attendance, Mr. J. C. Armer, '06, presiding. The chief subject of discussion centered on research scholarships, especially those carried on by Messrs. Dobson and Shaw during the past year. Professor Rosebrugh was present and at the suggestion of Mr. Armer, outlined the work that Professor Price and Mr. Dobson were doing. He dwelt upon the importance of minute accuracy in the adjustment of the oscillograph to be used in taking observations upon the high tension transmission lines on which Mr. Dobson is operating. He recommended an extension of the scholarship, as the labor expended to that end was not commensurate with the results thus far obtained, as the magnitude of the task was much greater than that which corresponds to six months of work. He suggested a further six months, or at least a sufficient time to get the proper returns for the labor expended upon it.

Mr. Dobson described the apparatus as being in readiness to obtain the most accurate of results and emphasized the absolute necessity of such accuracy before taking any observations.

Professor Price expanded upon the difficulties in getting actual facts instead of alleged facts in connection with the experimental work. He instanced the nature of their endeavors so far as having been successful in obtaining accuracy. He described the remaining part of the research work as being a few experiments upon the actual transmission line, to be supplemented by a long study of the results obtained on the film.

Relative to Mr. Shaw's work, Professor Bain touched upon the enormous use of turpentine and mentioned the price as having risen from sixty cents to over one dollar during the past several years. The bulk of this ingredient of many of our industrial paints, etc.,

was obtained, he said, from the enormous pine forests of Georgia and Carolina, the raw product, by distillation, resulting in a volatile liquid known as turpentine and a solid, resin. Mr. Shaw proposed to investigate pinon wood, which was very resinous. He spent several months endeavoring to extract turpentine and succeeded, but the liquid was not in sufficient quantities to insure the operation to be of commercial value. Finishing the samples on hand, and in the interim awaiting a new supply, Mr. Shaw undertook a new problem. This dealt with linseed oil. The oil was known to absorb oxygen from the air, forming a skin which makes its adaptability to paints most important. Being manufactured from flaxseed the supply is limited. Any practicable substitute might, therefore, yield a promising return.

Cottonseed oil was not a drying oil but if this property could be conferred upon it, it would be a great achievement in the interests of paints and pigments. Mr. Shaw spent several months upon this work and achieved a partial success. He converted about fifty per cent. of cottonseed oil into a drying oil. The balance, however, made the process of drying a slow one and, therefore, not a practical success. Numerous auxiliary substances were tried, but the results obtained to date had no immediate promise of commercial value.

A new shipment of pinon wood had arrived a month previous to this meeting, and jack pine was also being tried. Indications pointed to the probability of something profitable being the result, although the work had not progressed sufficiently far for results. Professor Bain mentioned Mr. Shaw's work as having been most faithful and energetic.

Professor Haultain expressed gratification upon the success attendant upon the scholarship movement up to the present. He believed that the lack of results having a commercial value was not without its favourable features. He was of the opinion that such should not be sought after. The primary importance of the scholarship idea was one of actual training of men in the work of research. The accompanying stimulus to the staff when called upon for its aid was also of great importance. The movement was elevating the standard of the School and was expressing at the same time the loyalty of the graduates.

It is the support and enthusiasm of a graduate body according to Mr. Haultain's belief that forms the foundation upon which the scholarship movement rests. Ten dollars from a graduate of the Institution is worth more than many times that sum from an outside man of wealth.

Mr. Oliver expressed the work of the executive in binding together the whole graduate body in this movement as being great and not without handicap. The tenseness of business prevents a man from keeping a close touch with the School after he leaves it, and once his interest is permitted to lag, an arousal of enthusiasm is not easily induced. He corroborated the remarks of Professor Haultain relative to results of monetary value from our scholarships. They were not to be looked for and were to be hoped for to a very

small degree. The training was, in his estimation, the most important feature. He expressed himself also as being adverse to going beyond the bounds of the graduate body for contributions to the fund.

Three members of the executive committee of the Association resigning each year, the election of their successors took place. The successful candidates were A. F. Macallum, '93, A. E. Gibson, '02, and H. T. Routly, '06.

Following this part of the proceedings, Mr. Armer invited Dean Galbraith to address the graduates, which he did with a great deal of praise for the research work that was being done. He expressed a hope that the scholarship movement would be continued as it was doing a great deal for the Faculty as well as for the men themselves.

Subsequent Executive Meetings

At an executive meeting held on April 22nd, the term of Mr. Dobson's scholarship was extended sufficiently to allow the completion of the work, such term not to exceed six months. At this meeting also, Mr. E. W. Oliver, '03, was elected president for the year, and Mr. G. R. Mickle, '88, was elected vice-president. Mr. H. Irwin, '09, was re-elected secretary-treasurer.

On May 9th, Mr. Shaw's thesis, covering his work as research scholar was received and accepted. The question of an annual fee for membership on the Toronto branch of the Association was discussed, and it was decided to approach all School men in the city and within a radius of fifty miles for a fee of one dollar, as authorized by a clause to that effect in the by-laws of the Association adopted May 18th, 1911. This is to defray the petty expenses of the organization and to be used to promote its healthy development as representative of all School men within reach.

THE ELECTRICAL CLUB

The results of the election in the University of Toronto Electrical Club to the various offices for the coming year are as follows: President, H. M. Black; Vice-President (to be elected from the III year in the fall); Secretary-Treasurer, E. D. W. Courtice; IV year Councillor, J. D. Peart; III year Councillor (also to be elected).

Several very satisfactory meetings have been held since the last announcement of the Club in APPLIED SCIENCE. On January 23rd a meeting was addressed by Mr. Yeates on the commercial side of the Hydro-Electric System. In his discourse he outlined very clearly the manner in which the rates for the different municipalities were struck, showing some of the difficulties met with in accomplishing a satisfactory arrangement. Early in February Mr. W. P. Dobson, research Fellow for the Engineering Alumni Association, lectured upon the Toronto Hydro-Electric System. Professor Durley of McGill University gave an address on February 26th upon the subject, "The Heating and Ventilation of Buildings." He dwelt more particularly upon the latter, it being the more difficult proposition of



UNIVERSITY OF TORONTO ELECTRICAL CLUB EXECUTIVE, 1912-13.

Standing: P. H. MILLS, E. D. W. COURTICE.

Seated: R. G. MATTHEWS, Vice-President; R. J. ALLEN, President; W. B. BUCHANAN, F. R. SIMS, Sec.-Treas

the two. The speaker's remarks proved very interesting to the members, who were present in greater numbers than at any other meeting of the year.

In March, Professor Price gave his address on the "Oscillograph." The Faculty is most fortunate in having among its equipment one of the three oscillographs in Canada. The attendance at the meeting showed that the students appreciated this fact. Quite a number of graduates took advantage of the occasion to learn the latest improvements which had been applied to the instrument.

THE SANITARY ENGINEERS' CLUB

The IV year men in this course supplemented their academic work by a tour of inspection through the larger cities of the New England States. The executive in charge of the trip had made most satisfactory arrangements, and the whole enterprise was a complete success. It took place early in February. The party went first to New York and to Columbia University where they were received by Professor Blanchard of the Roadways Department. The highway laboratories of the University were visited, and among other points of interest was an experimental system of pavements laid for the purpose of determining the value of different paving materials. Other places in the vicinity of New York, which were visited, were Plainfield, N.J., where septic tanks and contact filter beds were the chief items of interest; Hoboken, with its slow sand filters, garbage incinerator and a small sewage plant under construction, and Jamaica Island, with its system for the mechanical precipitation of sewage. The Croton Dam was likewise visited. The immensity of this undertaking greatly impressed the members of the party.

After spending four days in and around New York they proceeded to Philadelphia where a large incinerator in the process of construction, and also the Torresdale filters, were examined. The system of filtering the water for the city of Philadelphia is very complete in every way. The water is taken from the river in an almost viscous condition having flown through the coal regions of Pennsylvania. It first passes through roughing filters to a secondary system of fine slow sand filters from which it is collected in a reservoir, and chlorinated before proceeding to the service mains.

The party also saw an Imhoff tank sewage disposal system the capacity of which exceeds 2,000,000 gallons per day. Sprinkling filters were used in connection with the tank, the flow being regulated by Butterfly valves specially arranged for the purpose by Mr. Sutherland of the sewage disposal department, City of Philadelphia.

Baltimore was the next city visited where another system consisting of septic tanks and sprinkling filters was examined. Sufficient fall was available in this plant to generate at the outlet enough electrical power (200 h.p.) for the requirements of the system. A large reinforced concrete aqueduct in the process of construction also aroused considerable interest. It is to carry a river through the City of Baltimore, under a street upon which is to be constructed a viaduct for elevated traffic.

EXAMINATION RESULTS, 1913

Professional Degrees

The following graduates have completed the requirements for professional degrees:—F. A. Dallyn, '09, the degree of civil engineer (C. E.); E. A. James, '04, the degree of civil engineer (C. E.); C. H. Marrs, '02, the degree of civil engineer (C. E.); D. L. H. Forbes, '02, the degree of mining engineer (M. E.); A. G. Christie, '01, the degree of mechanical engineer (M. E.); E. H. Darling, '98, the degree of mechanical engineer (M. E.); G. J. Manson, '04, the degree of mechanical engineer (M. E.); R. S. Smart, the degree of mechanical engineer (M. E.); P. H. Mitchell, '03, the degree of electrical engineer (E. E.).

Scholarships

The Boiler Inspection and Insurance Company's scholarship for general proficiency in the third year mechanical engineering, has been awarded to Mr. E. D. W. Courtice.

FIRST YEAR

Candidates whose names are followed by brackets must pass supplemental examinations in the subjects indicated.

Civil Engineering

Honors—E. B. Allan, T. E. Armstrong, L. F. Barnes, E. Crosby, R. S. Dale; G. R. Dashwood, J. H. Eastwood, C. Edmonds, D. G. Hagarty, G. C. Hagedorn, K. B. Jackson, R. W. Kirby, F. J. Matthew, B. Mitchell, C. E. Newman, E. A. O'Callaghan, W. W. Ritchie, C. E. Rogers, S. R. Ross, R. L. Seaborn, R. L. Sievewright, W. H. Stark, J. A. Sureda, H. M. Wallis, R. C. Ward.

Pass—D. P. Barr (trig.), R. R. Brown (field work, accounts), R. K. Downie, C. E. Gage (trig.), C. K. Hoag (surveying, accounts), L. H. Ingersoll (elem. chem.) J. R. Kirby, L. A. Lee, M. Levy, R. M. MacInnes (field work), F. McGinn, F. T. McPherson, O. Margison, H. B. Norwich, V. R. Pfrimmer, E. E. Smith (trig.), H. S. Smith (algebra, dynamics), C. Smyth, G. B. Snow (trig.), W. A. Speight (algebra, dynamics), M. S. Taylor, E. C. Walker (dynamics).

Mining Engineering

Honors—B. A. McCrodan, D. M. Masson.

Pass—G. Hanmer (algebra, elem. chem.), R. M. Hare (trig., dynamics), F. W. Norton (accounts), H. C. Rose (algebra, elem. chem.), H. D. Wallace (algebra), J. F. Young (elem. chem.).

Mechanical Engineering

Honors—W. K. Greatrex, R. W. Kirn, J. P. Russell, L. L. Youell.

Pass—F. S. W. Ball (accounts), H. E. B. Breuls, J. A. N. Ormsby (elec. and mag., elem. chem.), R. A. Macdonald, F. Merry, A. Van Etter (electric circuits, elem. chem.), H. A. Washington, D. M. Watts (dynamics, accounts).

Architecture

Honors—R. T. C. Hoidge, T. W. McLellan.

Pass—L. Husband (trig.), R. E. Lapp (trig.), F. H. Marani (accounts), G. C. Rennie (accounts), A. F. Swinnerton (algebra, trig.).

Applied Chemistry

Honors—W. G. Birrell, H. B. Head, A. T. Purcell.

Chemical Engineering

Honors—C. C. Anderson, D. Boyd, C. E. Oliver.

Pass—S. J. Krug (elec. and magnetism), W. H. O'Reilly (elec. and mag.).

Electrical Engineering

Honors—W. D. Armstrong, H. A. Babcock, F. W. Booth, J. R. Chapman, S. K. Cheney, L. L. Cunningham, L. G. Dandeno, T. A. Daniel, M. P. Fallis,

E. G. Gurnett, A. E. Harkness, G. E. Nott, J. S. Panter, J. M. Watson, A. R. Wells, H. S. Weppner, A. B. Whaley, J. S. Wilson.

Pass—N. R. Adams, R. K. Armstrong (elec. and mag., accounts), H. S. Brown (trig., dynamics), R. A. Cross (elec. lab., trig.), K. Cumming (accounts), R. L. Flegg (elec. and mag.), R. A. Fraser, H. M. Grasett, M. Johnson (trig., elec. and mag.), J. Kelleher (accounts, trig.), G. F. King (trig., accounts), C. R. Klingensmith (algebra and elec. circuits), L. Levesque (elec. and mag., elem. chem.), H. B. Little, T. W. Martin, R. T. Park (trig., elec. circuits), H. Reed (dynamics, elec. circuits), W. A. Smelser (dynamics, elem. chem.), E. W. Smithson, J. R. Sullivan (German), K. E. Tobin, R. Tudhope, R. H. Wilson (elec. and mag.).

Metallurgical Engineering

Honors—O. H. Hugill.

SECOND YEAR

Civil Engineering

Honors—P. Bennett, E. D. Brouse, L. R. Brown, W. G. Brown, F. M. Buchanan, W. R. DaCosta, N. H. Daniel, W. L. Dickson, W. J. Fulton, E. R. Grange, C. E. Hogarth, C. W. H. Jackson, G. W. F. Johnston, R. E. Laidlaw, C. R. McCort, J. P. McDonald, K. D. McDonald, G. Mitchell, C. H. Ney, H. S. Nicklin, C. F. Porter, W. B. Redmond, A. A. Richardson, E. H. Scott, R. G. Scott, F. E. Weir, J. N. Williams, J. C. Wilson, H. A. Wood.

Pass—L. S. Adlard, A. C. Anderson (spher. trig., org. chem.), G. A. Arksey, F. D. Austin (calculus, dynamics), R. C. Beswick (chem. lab., org. chem.), A. P. Black (spher. trig., org. chem.), R. M. Cockburn, J. D. Cook (calculus), A. B. Crealock (optics, hydrostatics), E. V. Dever (calculus), W. L. Dobbin (org. chem.), G. A. Downey, A. C. Evans, H. S. Falconer (spher. trig., des. geom.), W. R. Fraser, W. G. French, R. D. Galbraith, C. N. Geale (optics, org. chem.), G. A. Gooderham (mineralogy lab., st. of materials), G. S. Gray (mineralogy lab., banking and finance), M. Gurofsky (optical lab.), E. D. Gray (st. of mat., field work), R. W. Harris (spher. trig., des. geom.), C. E. Hastings, C. Hayward (optics), E. H. Jupp, W. E. Lockhart (calculus, spher. trig.), R. G. Lye (astronomy, org. chem.), D. F. McGuggan, E. V. McKague (calculus), G. D. Maxwell (surveying, org. chem.), W. H. Meitz (astronomy), J. T. Mogan, B. M. Morris (astronomy, org. chem.), D. E. Murphy (calculus), M. A. Neilson (calculus, optics), P. L. Pearce (surveying, I. yr. dynamics), H. M. Peck, J. E. Porter, N. L. Powell (calculus), W. E. Raley (optics, org. chem.), C. C. Rance, G. Rankin (mineralogy lab., optics), J. T. Rose (spher. trig., org. chem.), J. S. Sheehy, C. N. Simpson (banking and finance), P. L. Stevens (optics, bank. and fin.), L. B. Tillson (calculus), J. A. Tom (org. chem.), J. A. Vance, L. P. Vezina (optics, algebra), J. H. Wallis.

Mining Engineering

Honors—W. T. Hall, J. E. Hanlon, L. T. Higgins, I. M. Macdonell, J. M. Muir, S. Peterkin, H. Stewart, J. B. Stitt, J. E. C. Stroud, W. S. Wilcock.

Pass—W. Allan (hydrostatics), M. R. Arthur (org. chem., inorg. chem.), P. G. C. Campbell (org. chem., inorg. chem.), F. N. D. Carmichael (inorg. chem., metallurgy), E. R. Emerson (inorg. chem.), M. S. Haas, W. F. McCaffrey, G. R. Mansell (st. of mat., inorg. chem.), F. L. Mills (french, algebra), B. C. Tomlinson (org. chem., inorg. chem.).

Mechanical Engineering

Honors—W. S. Kidd, R. H. Lloyd, W. R. McGie, A. N. Payne, F. G. Reid, C. A. Smith.

Pass—J. Gray, A. H. Smyth (des. geom.), H. C. Taylor (calculus, electricity).

Architecture

Honors—M. Denison, A. Morris.

Pass—H. J. Burden (calculus, optics), K. C. Burness (calculus), R. W. Catto (calculus, algebra), J. J. Davidson, G. R. Edwards (calculus, hydrostatics),

T. S. Graham (french), R. B. McBride (hist. of ornament), G. W. Rutter (calculus, banking and finance).

Analytical and Applied Chemistry

Honors—S. H. Feather.

Pass—W. P. Brodie, F. F. Hicks, H. Kohl, W. D. Morris, W. Uffelman (geol.), L. T. Watson (metallurgy, trig.).

Chemical Engineering

Honors—J. E. Breithaupt, A. A. Swinnerton.

Pass—L. G. Glass (calculus, electricity), H. M. Ramsay (calculus, trig.).

Electrical Engineering

Honors—C. G. Davey, W. A. Dean, J. Dibblee, R. B. Elliott, W. H. R. Gould, A. G. Ironside, H. C. Karn, C. R. Keys, G. W. Lawrence, A. C. Ross, W. A. Steel, A. N. Suhler, A. L. Ward.

Pass—W. V. Ball (calculus, optics), T. R. Banbury (hydrostatics), V. A. Beacock (hydrostatics), W. H. Bonus (optics, org. chem.), H. C. Budd (calculus, optics), J. M. Carswell (org. chem.), J. P. Cavers (des. geom., hydrostatics), F. H. Chandler (electricity, banking and finance), W. W. Code (calculus, org. chem.), G. P. Davidson (calculus, steam engines), C. W. Dobbin, H. R. Hopkins, T. P. Ireland (des. geom.), K. A. Jefferson (anal. geom.), A. H. Macfarlane (calculus), W. R. Meyer, E. M. Monteith (calculus, electricity), W. F. P. Purdy (electricity), J. Richmond (steam engines, org. chem.), A. S. Robertson, E. W. Savage, N. F. Seymour (hydrostatics), W. G. Shier, J. D. Stone, A. N. Taylor, F. W. Ward.

THIRD YEAR

Civil Engineering

Honors—J. L. Alton, H. J. Bedard, J. H. W. Bower, D. H. Campbell, J. J. Campbell, W. Cuthbertson, R. Dashwood, R. D. Davidson, F. W. Douglas, O. M. Falls, J. J. Hanna, B. B. Hogarth, R. P. Johnson, H. O. Leach, R. E. Lindsay, H. N. Macpherson, D. A. McCaw, R. C. McDonald, J. A. P. Marshall, F. C. Mechin, E. P. Muntz, C. Noeker, R. G. Patterson, H. L. Sheppard, G. E. Treloar, F. T. Van Dyke, H. W. Wagner, H. P. Wilson.

Pass—E. M. Abendana, (III. year surveying), F. C. Adsett (astronomy and geodesy), E. L. Bedard (biology), J. T. Belcher, S. G. Bennett (surveying, limited cos.), P. V. Binns (hydraulics), J. M. Blyth (geology), R. M. Christie, (theory of construction, geology), J. C. Christner (th. of structures, limited cos.), W. W. Code (II. year eng. chem., geology), J. W. Crashley (ast. and geod., hydraulics), G. F. Dalton (th. of struc.), J. A. Elliott, H. E. Byres, G. O. Fleming, J. L. Foreman, C. H. R. Fuller (biology), R. W. Guinlock (th. of struc., hydraulics), J. H. Hawes (hydraulics), L. T. Hayman, S. A. Hustwitt (Eng. chem.), J. Kay (th. of strucs.), J. A. Knight, C. A. Macdonald (surveying), S. B. McGill, W. G. Millar (ast. and geod.), A. S. Miller (th. of strucs., biology), J. S. Mitchell, J. R. Montague (ast. and geod.), G. J. Mullins (ast. and geod.), J. B. Nicholson (th. of strucs., hydraulics), W. M. Omand (surveying, th. of structures), J. A. Owens, A. H. Parker, C. W. Pennington (ast. and geod., th. of strucs.), C. V. Perry, P. H. Raney, R. H. Rice (des. geom., th. of strucs.), F. S. Rutherford (ast. and geod., th. of strucs.), N. E. D. Sheppard (th. of strucs., hydraulics), S. Shupe (ast. and geod., heat), C. E. Sinclair (th. of strucs., geology), B. Sinclair (hydraulic lab.), J. B. Skaith (geology), H. M. Smith (th. of strucs., geology), N. L. Somers (hydraulics), I. R. Strong, C. N. Temes, J. A. Tilston (hydraulics, photography), H. O. Waddell, H. M. Wallace, P. L. Whitley (biology).

Mining Engineering

Honors—S. D. Ellis, J. R. Gill, W. A. Macdonald.

Pass—F. C. Andrews (electricity, ore dressing); H. R. Banks, J. M. Cart (photography, ore dressing), E. V. Chambers, J. S. Fleming (anal. chem., metal-

lurgy), D. S. Halford (assaying lab., mining), W. Hutchings (hydraul., geology), S. A. Lang, H. J. MacWenzie (anal. chem., ore dressing), P. W. Meahan, W. D. Powell (anal. chem., mining), J. G. Shepley (assaying lab., mining), G. M. Smyth (hydraulics, ore dressing), G. B. Taylor, J. S. Taylor, R. W. Young.

Mechanical Engineering

Honors—H. M. Campbell, E. D. V. Courtice, H. F. Elliott, G. H. Hally, H. W. Maxwell, J. G. Scott.

Pass—H. H. Brown, K. M. Clipsham (electricity), A. D. Delamore (const. notes, electricity), W. H. Hall (hydraulics, electricity), H. S. Kerby, J. A. Kerr, B. Mackendrick (theory of structural electricity), P. H. McQueen (hydraulics, ltd. cos.), S. G. Tackaberry (hydraulics), E. H. Tennant (electricity), M. F. Verity (th. of structs, electricity).

Architecture

Honors—W. C. Skinner, A. C. Wilson.

Pass—E. E. H. Hugli, N. G. Keefer (th. of structs.), J. M. Robertson (modeling, th. of structs.).

Analytical and Applied Chemistry

Honors—J. G. G. Frost, A. J. Holden, O. G. Lye, W. E. Phillips.

Chemical Engineering

Honors—C. N. Candee, W. E. Milligan, A. E. Wigle.

Pass—D. Morrison (org. chem., anal. chem.), A. W. Sime (org. chem., th. of structs.), E. A. Twidale.

Electrical Engineering

Honors—H. M. Black, W. D. Brown, A. W. Crawford, H. J. Franklin, E. I. Gill, C. I. Grierson, A. S. Jannati, C. W. Latimer, A. M. MacKenzie, R. G. Matthews, P. H. Mills, C. L. Nicholson, J. D. Pear, G. O. Philp, F. M. Serves, G. C. Storey, W. S. Tull.

Pass—C. E. Armer, H. A. Campbell (alt. cur., elec. des.), C. E. B. Corbet (thermo., alt. cur.), H. C. Edwards (electro-chemistry), D. G. Ferguson (eng. chem.), D. T. Flannery (electro-chemistry), G. D. Gray (mag. and elec. alt. cur.), R. C. James, J. I. Kamman, G. E. Kewin (mag. and elec., alt. cur.), W. E. Longworthy (alt. cur.), N. H. Lorimer, J. S. McIntyre (thermo., II. yr. chem. lab.), D. L. McLaren, J. A. Marshall (hydraulics), A. S. Robertson, H. D. Rothwell (electro-chemistry, ltd. cos.), R. O. Standing (hydraulics), E. C. R. Stoneman.

FOURTH YEAR

Civil Engineering

Honors—F. Alport, C. R. Avery, W. B. Beatty, B. S. Black, W. M. Brock, G. M. Cook, J. S. Galbraith, E. R. Gray, R. L. Hearn, H. J. Heinonen, O. Holden, H. R. Mackenzie, K. F. Mickleborough, W. C. Murdie, N. F. Parkinson, J. E. Perron, J. M. Riddell, J. E. Ritchie, C. S. Robertson, H. L. Robin, L. Sewell, H. L. Seymour, J. M. Thompson, W. G. Ure, C. F. von Gunten.

Pass—F. W. Beatty, D. Blain, O. L. Cameron (th. of structures, III. yr.), L. L. Campbell, G. M. Carrie (geology), J. A. Coombe (th. of structs., III. yr., ast. and geod.), A. J. Dates, F. R. Fiddes, D. H. Fleming, A. M. German (hydraulics, thermo.), H. M. Goodman, A. G. Gray, J. R. Hamilton (th. of struct.), H. A. Hawley, A. W. Hayman (thesis, geology), J. T. Howard, E. T. Ireson (th. of struct., II. yr., french), G. R. Johnson (electricity, str. mat. lab., III. yr.), R. L. Junkin (electricity), J. S. Laing, T. V. McCarthy, A. R. MacPherson, W. H. MacTavish, W. L. McPaul, N. C. Millman, T. R. Moore (III. yr. ast. and geod.), F. J. Mulqueen, W. V. Oke, J. J. Phillips (III. yr. th. of structs.), H. C.

Quaill, B. H. Segre, W. A. Spellman (th. of structs.), D. Sutherland (electricity), R. Tasker (thermo., electricity), D. H. Weir, W. S. Winters (th. of structs.), R. F. B. Wood (electricity, geology).

Mining Engineering

Honors—R. W. Diamond, K. L. Newton, D. G. Sinclair, W. K. Thompson.
 Pass—C. A. Bell (metallurgy lab.), R. E. Binns (thesis), T. R. Buchanan, W. B. Caldwell (assaying lab., mining), H. A. Clark (chemical lab.), W. T. Curtis (electro-chemistry), W. H. Garnham (metallurgy lab.), D. A. S. Mutch, R. M. Trow (assaying lab., electro-chemistry).

Mechanical Engineering

Honors—A. S. Anderson, E. T. Cain, R. M. Carmichael, B. D. Clegg, R. A. Henry, L. W. Rothery, K. E. Shaw, F. R. Sims, C. A. Webster.
 Pass—B. H. A. Burrows, H. D. Davison (th. of structs.), F. F. Foote (th. of structs.), A. J. Gray, R. E. Watts (th. of structs.).

Architecture

Honors—L. C. M. Baldwin, B. R. Coon, H. D. Livingston, R. S. McConnell, R. W. Soper, H. Webster.
 Pass—B. Brown (electricity).

Analytical and Applied Chemistry

Honors—C. J. Otto.
 Pass—A. V. DeLaporte.

Chemical Engineering

Honors—G. E. Clarkson, K. S. MacLachlan.

Electrical Engineering

Honors—O. F. Adams, R. J. Allen, L. R. Brereton, W. B. Buchanan, T. R. C. Flint, H. G. Hall, T. A. Hill, T. F. Howlett, S. S. Kelly, G. J. Mickler, J. W. Peart, E. G. Ratz, C. C. Rous, A. A. Scarlett, M. C. Sharp, J. M. Strathy, D. J. Thomson, A. J. Wright.
 Pass—R. S. Bell (thesis, electric lab.), E. R. Bonter, J. H. Coleman, E. L. Deitch, W. G. Duncan, J. P. Hadcock, H. C. Harris, A. E. Kerr, C. E. Kilmer, A. G. Leslie (electrical lab.), G. L. Lillie, L. B. Lytle (electrical lab., electricity), H. A. MacKenzie (elect. lab., electricity), C. H. Russell, T. E. Torrance, H. E. Whately (thesis), L. P. Yorke, R. B. Young.

SUPPLEMENTAL EXAMINATIONS—PASSED

First Year Subjects

Trigonometry—J. A. Tillston, J. D. Relyea, H. C. Taylor, L. F. Gaboury, R. W. Harris.
 Elementary chemistry—W. L. Dobbin, D. M. Morris, L. P. Vezina, G. R. Edwards, N. F. Seymour.
 Algebra—C. Hayward.
 Dynamics—L. F. Gaboury, D. B. Gardner, J. McLaughlin, J. C. Meader.
 P. G. C. Campbell, H. C. Taylor, W. B. Patterson.
 Electricity and magnetism—W. F. P. Purdy, N. B. Brown.
 Accounts—M. Gurofsky, J. E. Tremayne, B. C. Tomlinson, J. J. Davidson.
 Analytical geometry—L. B. Tillson, L. F. Simpson.
 Building measurements—J. J. Davidson.

Second Year Subjects

Engineering chemistry—G. J. Mullins, H. P. Wilson, F. C. Andrews, J. I. Kamman, W. H. Hall.
 Calculus—B. W. Bemrose, H. A. Campbell, C. M. Jones, W. M. Ryan, S. G. Tackaberry, H. J. Mackenzie, A. S. Miller.
 Electricity—E. I. Gill.
 Organic chemistry—J. H. W. Bower, R. F. Davison, H. M. Smith.

- History of architecture—E. E. H. Hugli.
 Hydrostatics—E. E. H. Hugli, S. G. Tackaberry, N. E. D. Sheppard, J. H. Hawes, A. S. Miller.
 Mineralogy—E. B. O'Connor, I. R. Strome, W. Hutchings.
 Steam engines—A. K. Purdy, G. E. Kewin.
 Dynamics—W. M. Omand, F. S. Rutherford.
 Descriptive geometry—A. G. Scott.
 Optics—W. F. Omand, J. Ross.
 Spherical trigonometry—R. H. Rice.
 Surveying—D. S. Halford, R. H. Rice.
 Inorganic chemistry—J. A. Tilston, F. C. Andrews, G. M. Smyth, J. S. Taylor.
 Banking and finance—G. D. Tillson.
 Electrical Lab.—W. M. Philp.
 Mineralogical Lab.—G. J. Mullins, R. B. Sinclair, H. M. Smith, D. S. Halford.
 Chemical Lab.—J. A. Kerr, S. D. Ellis.

Third Year Subjects

- Electrochemistry—J. H. McKnight, T. F. Howlett.
 Theory of structures—W. T. Curtis, F. R. Fiddes, A. M. German, H. M. Goodman, J. R. Hamilton.
 Hydraulics—F. W. Beatty, O. L. Cameron, H. D. Davison, C. E. Kilmer, W. T. Curtis.
 Least squares—R. A. Paul, J. A. Coombs, F. J. Mulqueen.
 Astronomy and geodesy—D. H. Fleming, A. R. MacPherson, H. C. Quail.
 Limited companies—F. R. Fiddes.
 Engineering chemistry—G. R. Johnson.
 Biology—D. H. Fleming.
 Thermodynamics—H. A. MacKenzie, R. A. Paul.
 Photography—L. B. Lytle.
 Alternating current—R. A. Henry, R. B. Young.
 Electricity—H. A. MacKenzie.
 Electrical design—L. B. Lytle.
 Mining—H. A. Clark.
 Metallurgy—R. M. Trow.

Fourth Year Subjects

- Thesis—C. E. Richardson.
 Strength of materials—E. O. Ewing.
 Hydraulics—F. H. Wrong.

SUPPLEMENTAL EXAMINATIONS TO BE TAKEN

First Year Subjects

- Dynamics—R. R. Hewson, R. M. Speirs, L. Withrow, R. D. Jones, C. K. Macpherson.
 Elementary chemistry—J. C. Meader, J. L. Delisle, N. H. Korn.
 Trigonometry—J. L. Delisle, A. Fleming, G. G. Macdonald.
 Electricity and magnetism—J. D. Relyea.
 Algebra—S. J. Hubbert, W. B. Patterson, R. D. Jones.
 French—N. H. Korn.
 Accounts—G. G. Macdonald.

Second Year Subjects

- Engineering chemistry—C. P. Cotton, R. F. Davison.
 Calculus—C. P. Cotton, E. B. O'Connor, A. K. Purdy.

Fourth Year Subjects

- Electricity—R. E. Green.

No official announcement has been made by the University concerning the publication of a class list this year, and in all probability none will be printed. Students may obtain their standing in subjects, however, from lists posted upon the bulletin boards, upon their return in September.

DIRECTORY OF THE ALUMNI

This department began in November, 1912, and the entire list of graduates will be reviewed before the end of the year.

A number of corrections have been received bearing upon the part of the directory which has already been published, and our list of addresses is thus becoming more authoritative. If those whose names will appear during the next several months will assure themselves that our record of their location and employment is correct before publication, it will be improved still more, as there are some addresses upon our files that are long standing and hardly to be depended upon.

F (Continued)

Foster, W. J., '10. We have no address for him at present except his home address, Windsor, Ont.

Foulds, W. C., '10, is assistant manager of the Winnipeg branch of the Canadian Inspection Co.

Francis Walter J., '93, is the senior member of the consulting engineering firm of Walter J. Francis & Co., Montreal.

Francis, G. C., '08, whose home address is Verschoyle, Ont., has no business address with us.

Frankel, E. L., '11, is manager of Frankel Bros., dealers in metals and millstock, Toronto.

Fraser, A., '10, with the Toronto Iron Works, Limited, as chief engineer.

Fredin, J., '10, of London, Ont., has no other address upon the records.

Freeland, E. E., '11, is with the Department of the Interior, Ottawa, in the topographical surveys branch.

Freeman, T. E., '09, is in the designing offices of the Canadian General Electric Co., at Peterboro, Ont.

Freeman, J. R., '11, is in the drawing offices of the Dominion Bridge Co., at Lachine, Que.

Frid, H. P., '11, is a member of the firm of Frid-Lewis Co., consulting engineers on building construction with head offices in Winnipeg.

Frost, E. R., '09, is engineer on the construction of caisson and pier work for the Foundation Co., at Pitt River, B.C.

Fuce, E. O., '03, is carrying on a consulting civil engineering practice in Calgary, Alta., in partnership with W. A. Scott, '06.

Fuller, R. J., '11, is in the city architects' department, City Hall, Toronto, as structural engineer.

Fullerton, C. H., '00, is in New

Liskeard, Ont., where he has a practice as engineer and surveyor.

Fux, P. C., '07, is advertising manager for the Waterous Engine Works Co., Brantford.

G

Gaby, F. A., '03, is chief engineer to the Hydro-Electric Power Commission, with headquarters at Toronto.

Gagne, S., '01, deceased, April 25th, 1909.

Gall, H., '10, is assistant engineer to Frank Barber, bridge and structural engineer, Toronto.

Galletly, J. S., '07, whose home is in Brooklin, Ont., was on D. L. S. work in the west, when our last information was received.

Galt, G., '07, we have no address for him at present. He was at East Ely, Nevada, when last heard from.

Gardner, J. C., '03, is city engineer, Niagara Falls, Ont.

Garland, N. L., '90, is engaged in building and contracting in Toronto.

Garrow, A. B., '07, is assistant engineer, Main Drainage Dept., City Hall, Toronto.

Gear, S. S., '08, is city engineer of St. Catharines, Ont.

George, R. E., '03, has no address with us. He was in Dover, N. H., with the United Gas and Electric Co., some time ago.

Gibbons, J., '88, was in Ottawa, Department of the Interior when last heard from.

Gibson, A. E., '02, is assistant engineer with Roger Miller & Sons, engineers and contractors, Toronto.

Gibson, J. M., '10, is with Chipman & Power, in their Toronto engineering offices.

Gibson, M. M., '10, has Willowdale, Ont., for his home address. He is

with W. S. Gibson, O.L.S., Toronto, on general survey work.

Gibson, N. R., '01, is carrying on a consulting practice in Toronto as civil and hydraulic engineer.

Gibson, W. S., '04, has an engineering and surveying practice in this city.

Gillespie, P., '03, is associate professor, Department of Applied Mechanics, University of Toronto.

Gillies, A., '07, is resident engineer for C. H. & P. H. Mitchell, upon electric development work at Minnedosa, Man.

Glover, A. E., '09, is engaged in surveying in Edmonton, Alta.

Goad, V. A. E., '10, is a partner in the firm of the Chas. E. Goad Co., surveyors, Toronto.

Goldie, A. R., '93, is a member of the firm of Goldie & McCulloch Co., Limited, Galt, Ont., as manager.

Goodall, J. N., '04, is engaged in civil engineering in this city.

Gooderham, A. E., '09, is chemical analyst for Gooderham & Worts, Toronto.

Gooderham, J. L., '11, is assistant chemist in the distilleries of Gooderham & Worts, Toronto.

Goodeve, V. S., '10, is with the Toronto Hydro-Electric System in the engineering office.

Goodwin, A. C., '02, was with the Aluminum Co., Pittsburgh, Pa., when last heard from. We have no other address for him.

Goodwin, J. B., '92, is in Edmonton, Alta., in the Department of Public Works.

Gordon, J. P., '04, is assistant chief engineer, Hudson Bay Ry., LePas, Man.

Gordon, W. A., '10, is in Sundridge, Ont., where he has been engaged in the hardware business.

Gourlay, V. F., '10, is Toronto representative of the Packard Automobile Co.

Gourlay, W. A., '03, is assistant engineer, C.P.R., Victoria, B.C.

Graham, C. W., '06, is Chief Chemist, Dunlop Tire and Rubber Goods Co., Toronto.

Graham, E. B., '10, is with the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

Graham, G. W., '07, his home address is Eugenia, Ont. We have no record of his professional work.

Graham, D. A., '09, is resident engineer with the Canadian Northern Pacific Railway, New Westminster, B.C.

Grant, W. F., '98, is city engineer of Sault Ste. Marie, Ont.

Grant, R. R., '09, is engaged in surveying and contracting, with offices in Toronto.

Grasett, C. S., '07, is at his home in Barrie at present.

Grassie, C. A., '08, whose home address is Welland, Ont., is at New Westminster, B. C., on general survey work.

Gray, A., '04, is with the St. Lawrence Starch Co., Port Credit, Ont.

Gray, A. T., '97, is designing engineer on steam turbines, General Electric Co., Schenectady, N. Y.

Gray, J. E., '09, is with the Transcontinental Ry., Edmonton, Alta., as instrument man.

Gray, W. W., '04, is with the Edmonton, Light & Power Co., Edmonton, Alta.

Green, R. E., '11, is in the engineering department of the Toronto Power Co.

Greene, P. W., '06, is a member of the firm of Kortwright & Green, civil engineers, Toronto.

Greene, R. L., '10, is engineering salesman for the Canada Foundry Co., Toronto.

Greene, W. H., '09, is assistant city engineer, Moose Jaw, Sask.

Greenwood, W. K., '04, is town engineer of Orillia, Ont.

Guernsey, F. W., '95, is engineer for the Consolidated Mining & Smelting Co., at Trail, B.C.

Gulley, C. L., '08, is with the Northern Electric & Mfg., Co., Limited, Toronto, as sales engineer.

Gunn, W. W., '09, is in the Toronto office of the Dominion Bridge Co.

Gurney, W. C., '96, is vice-president of the Gurney Foundry Co., Limited, Toronto.

Guest, W. S., '00, is lecturer in Electrical Engineering, University of Toronto.

Guy, E., '99, the last address we had for him, was with Smith, Kerry & Chace, in the Winnipeg office.

